

(12) **UK Patent Application** (19) **GB** (11) **2 333 962** (13) **A**

(43) Date of A Publication 11.08.1999

(21) Application No 9902350.9

(22) Date of Filing 04.02.1999

(30) Priority Data

(31) 9802379.9 (32) 05.02.1998 (33) GB

(71) Applicant(s)

Stephen Bryce Hayes  
3 Cockcroft Place, CAMBRIDGE, CB3 0HF,  
United Kingdom

(72) Inventor(s)

Stephen Bryce Hayes

(74) Agent and/or Address for Service

Michael Waggett  
43 Fen Road, Milton, CAMBRIDGE, CB4 6AD,  
United Kingdom

(51) INT CL<sup>6</sup>

A61N 5/06

(52) UK CL (Edition Q )

A5R REHR

(56) Documents Cited

EP 0736307 A2 WO 98/51372 A1 WO 96/19809 A1

(58) Field of Search

UK CL (Edition Q ) A5R REHR

INT CL<sup>6</sup> A61N 5/06

ONLINE: EPODOC, WPI, JAPIO, CAS, BIOSIS,  
MEDLINE

(54) Abstract Title

**Method and means of adjustment of circadian rhythms**

(57) A method and means of adjusting the circadian rhythm of a human body by the application of light, extraocularly, to one or more areas of the body surface, at appropriate times and for appropriate periods, in accordance with a pre-determinable program is disclosed. The light may be applied to blood vessels lying in or below the skin.

Apparatus for adjusting the circadian rhythm of a human body comprises a programmable controller (10) provided with program-setting controls (16) and a display (17), mounted upon a wrist band (18), which also mounts a carrier (12) for a light source (14), powered by batteries housed within the controller (10). Flexible leads within the wrist band (18) connect the controller (10) to the light source (14) which is programmably energised to provide light to the inside of the wearer's wrist at appropriate times and for appropriate durations, to modify the circadian rhythm of the wearer.

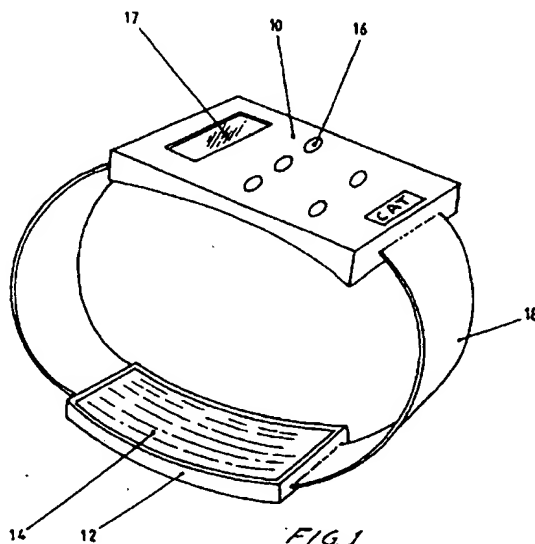


FIG. 1

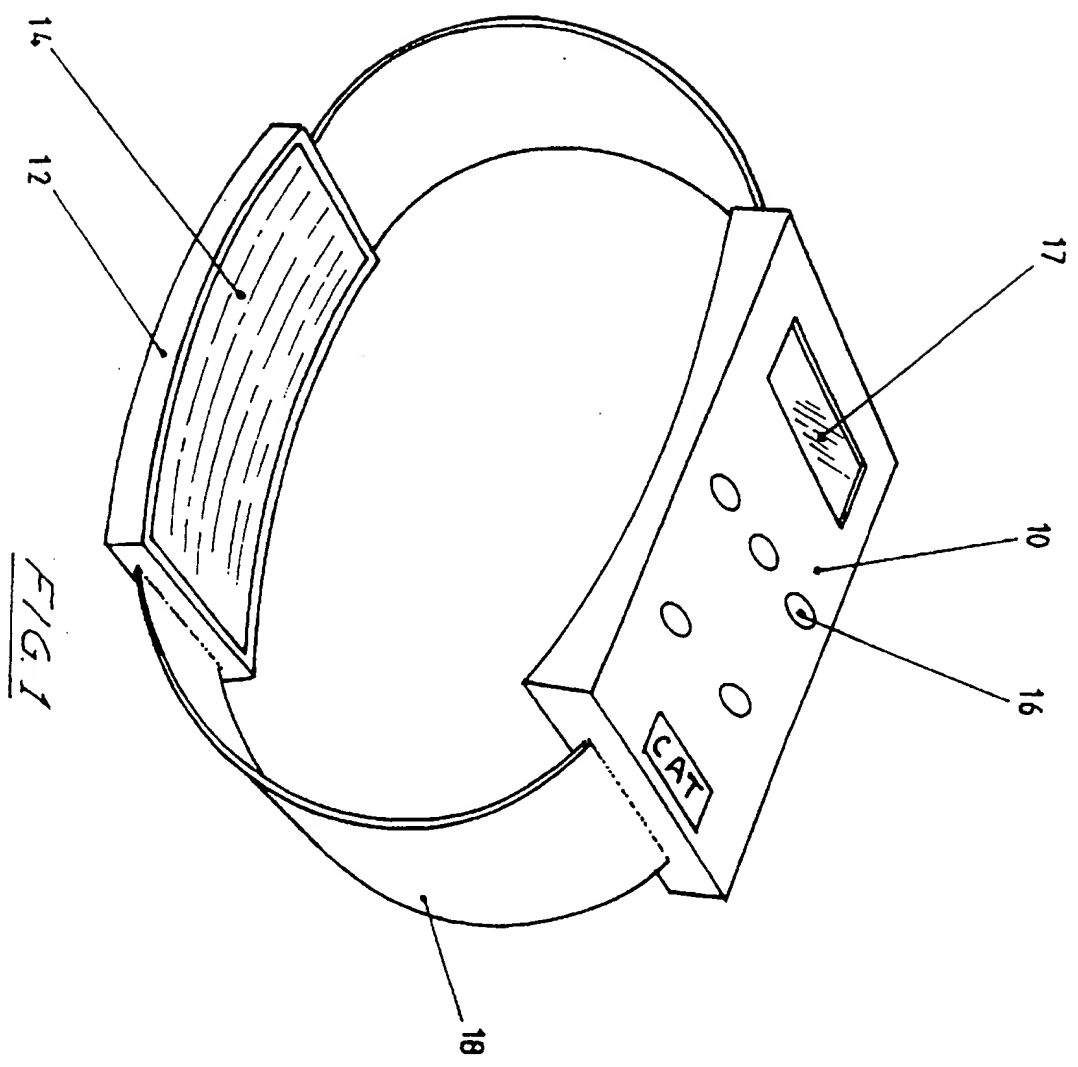


FIG 1

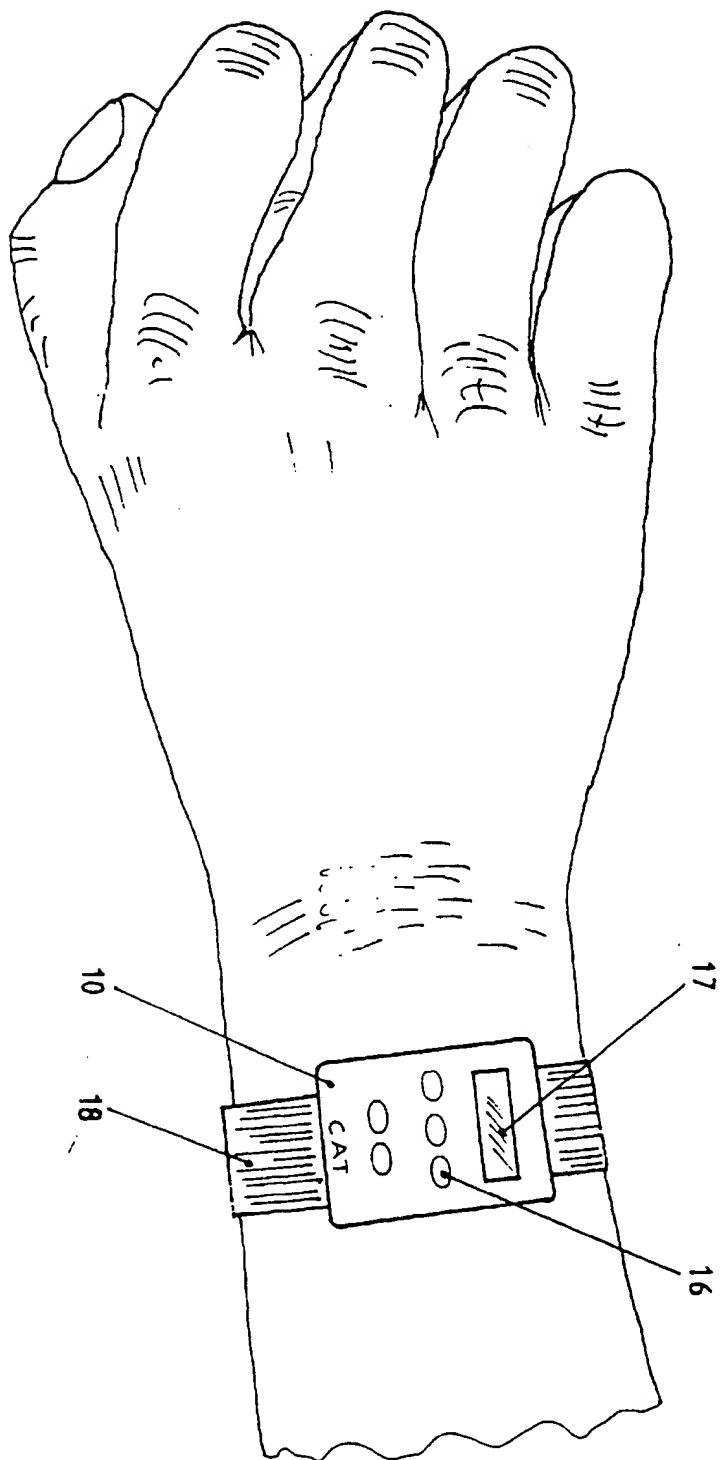


FIG. 2

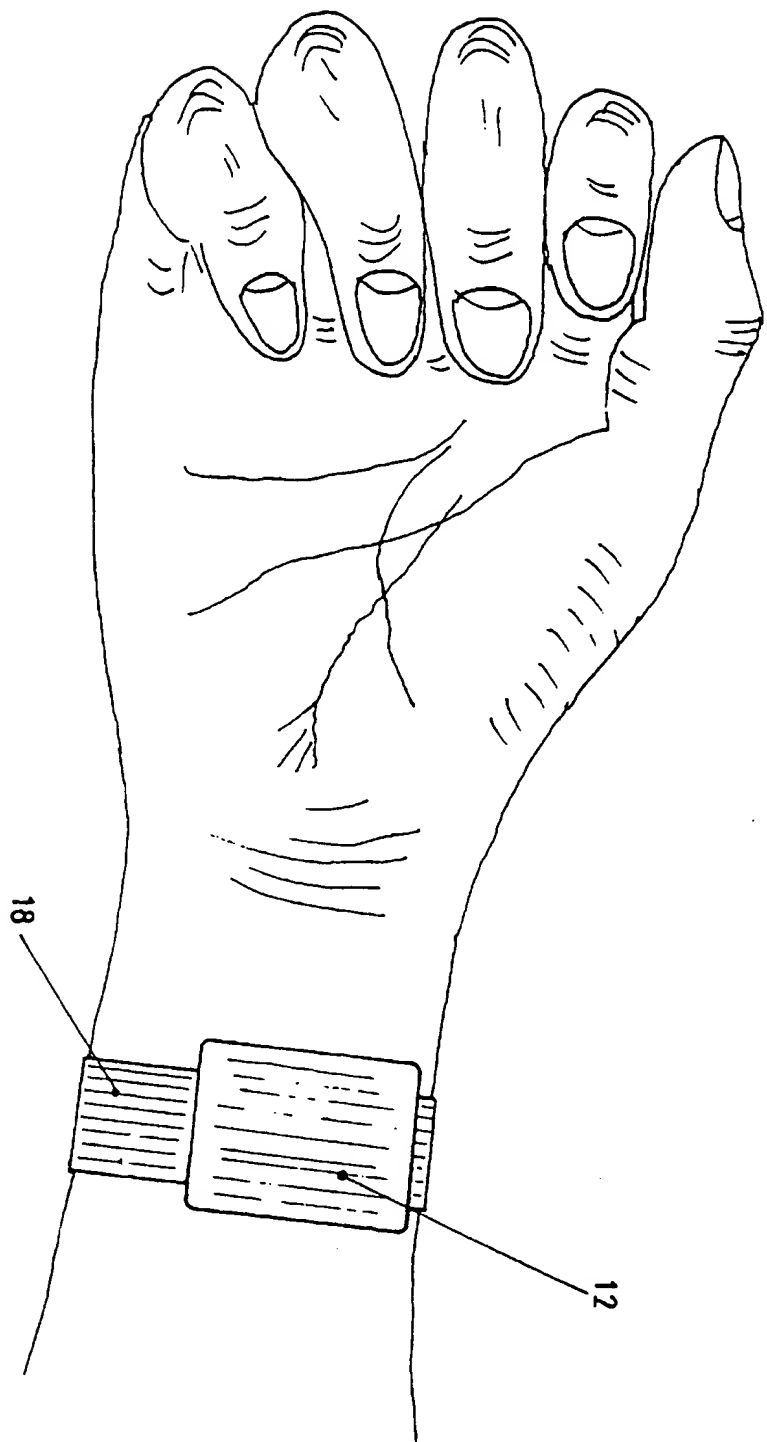
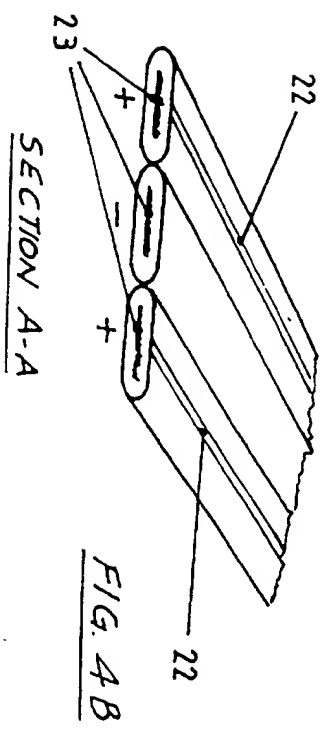
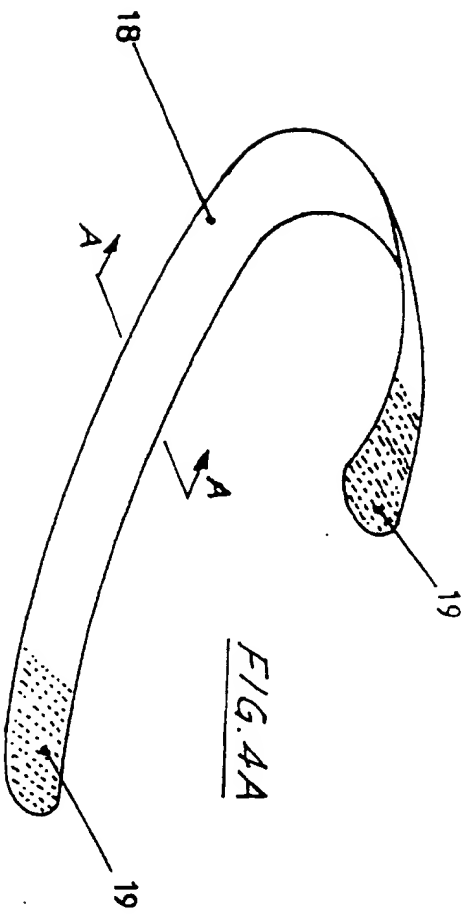


FIG. 3



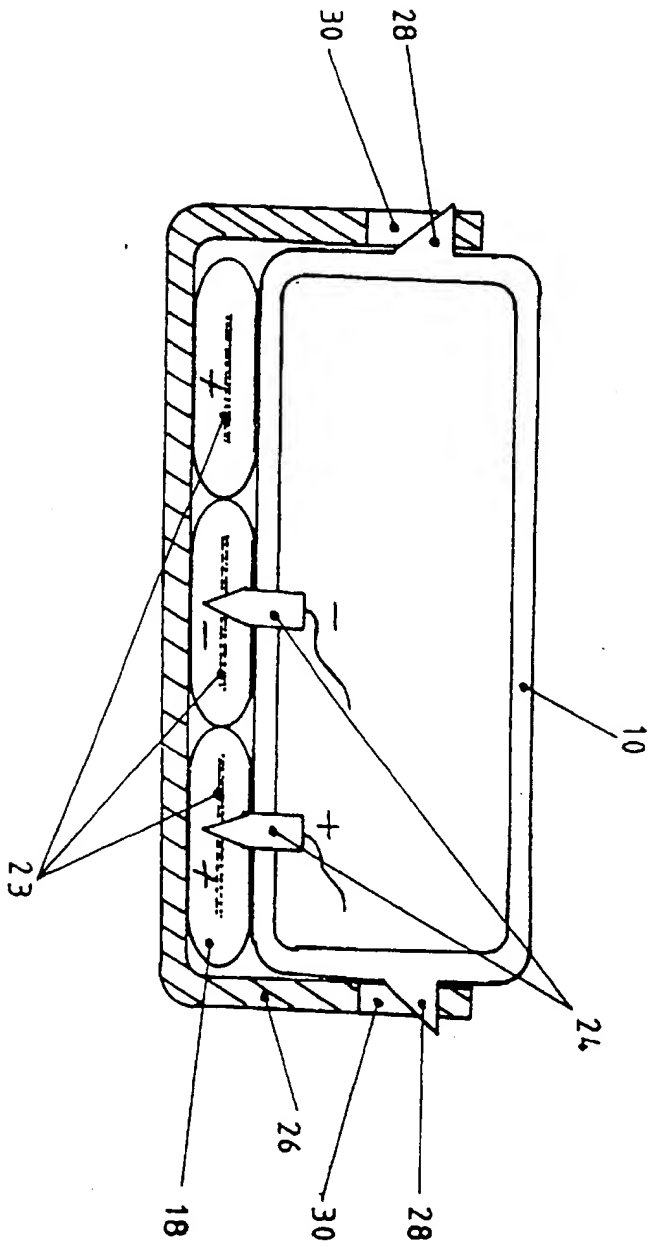


FIG. 4C

L/S

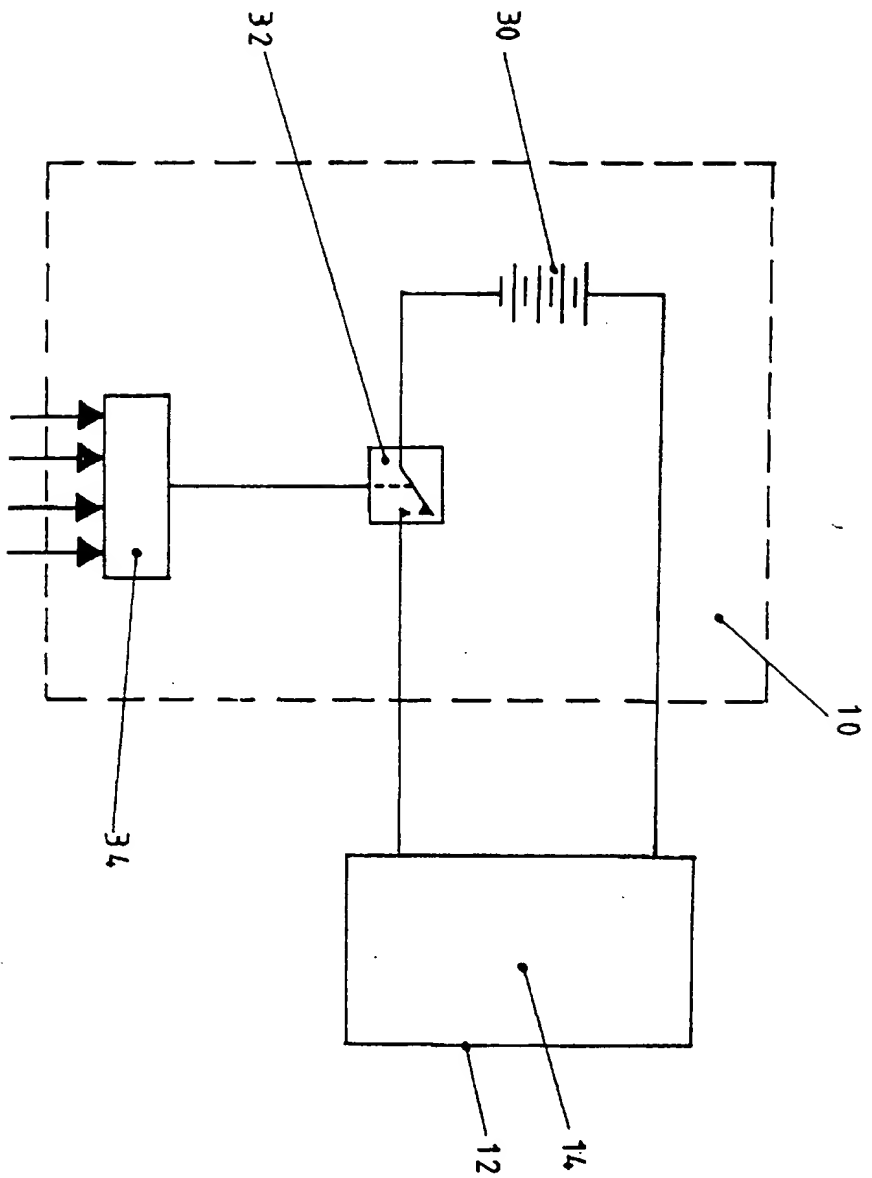


FIG. 5

7/7

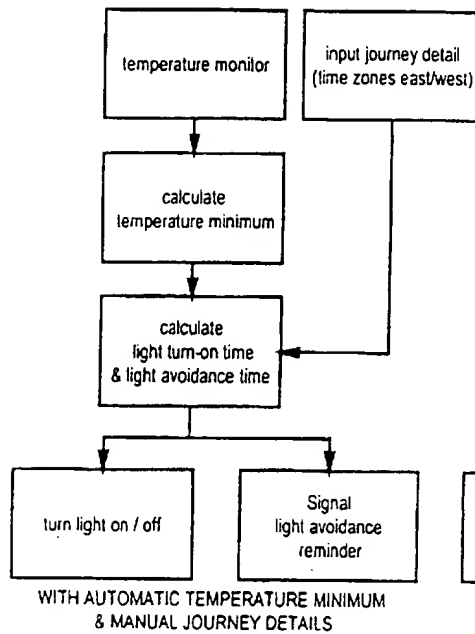


FIG 9

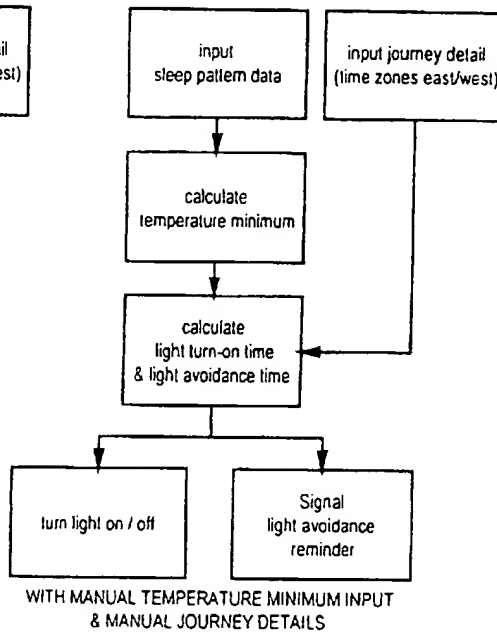


FIG 10

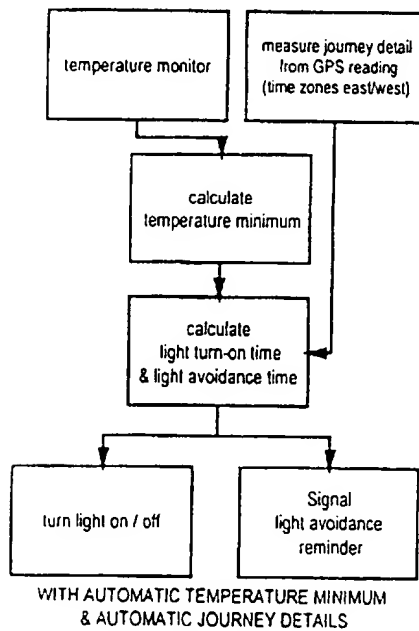


FIG 11

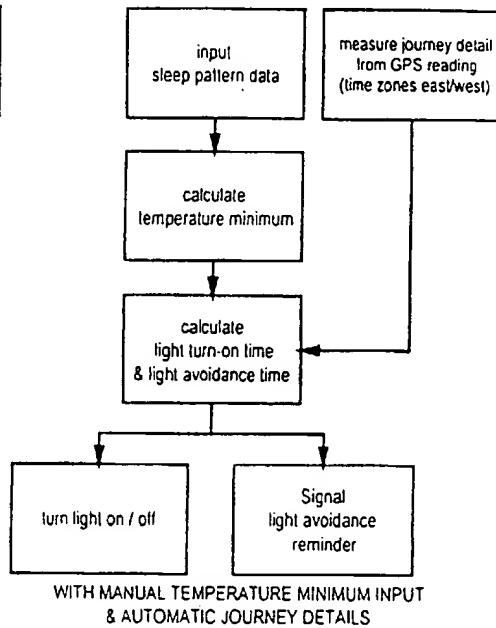


FIG 12

Method and means for adjustment of Circadian Rhythms

The present invention relates to a method and means for adjusting the circadian rhythm of a living body, more particularly of the human body.

It has long been known that an internal "body clock", i.e. the body's circadian rhythm, controls the timing of human biological functions such as eating and sleeping, so that travel to a different time zone can give rise to feelings of disorientation and malaise until the internal "body clock" has adjusted to local time.

It is known that it is possible to adjust the human "body clock" by the use of precisely timed exposure to bright light via the eyes, to cause the body clock to synchronise more rapidly with the new time zone.

One means of achieving this is by means of a light visor worn on the head which, under the control of a user, exposes the eyes of a subject to bright light at appropriate times, and for suitable durations, to produce the necessary adjustment of the body clock, either during or subsequent to a journey across time zones.

However use of a light visor in an aircraft or other public place is a disincentive to users to make the most effective use of the treatment i.e. during the course of a journey to a different time zone, and has deterred many who would benefit from such treatment from undergoing it.

It has latterly been shown that the human circadian

rhythm can be susceptible to adjustment by means of extraocular radiation, and it is an object of this invention to make use of this phenomenon to provide an improved method and means for adjustment of the circadian rhythm of a human body.

In accordance with one aspect, the present invention provides a method of adjusting the circadian rhythm of a human body by means of the application of light, extraocularly, to one or more areas of the body surface, at appropriate times and for appropriate periods, in accordance with a pre-determined program, thereby to cause adjustment of the body circadian rhythm.

The application of light is preferably to blood vessels lying in or below the skin of the body, preferably to blood vessels lying in or below the skin surface of the inner wrist or of the skin surface to the rear of the knee.

From another aspect the invention provides means for applying light, extra-ocularly, to an area or areas of the surface of a human body, in combination with means for controlling the periods and durations of the application of light, thereby to cause adjustment of the circadian rhythm of the body.

The means for applying the light may comprise one or more light sources mounted within a carrier capable of being applied to a body surface.

The carrier is preferably attachable to the body surface, for example by means of a strap or straps, or the like, and the carrier may be partially flexible in order

that it may be wrapped around a curved body surface.

The light source may comprise one or more electrically-powered light emitting devices, for example light emitting diodes or krypton lamps.

The light source may be powered from a portable electrical power source, preferably mounted upon the body, through a flexible braided conductor, which may be woven into or otherwise incorporated in one or more of the strap or straps for attaching the carrier to the body surface.

The light source may be connected to the electrical power source through controlling means, which may be a switch, manually operated according to provide light at the appropriate times and for appropriate durations, in accordance with a previously determined program.

The controlling means may include timing means capable of being pre-programmed to provide the necessary switching of the light source without further intervention of the subject.

The controlling means may further comprise means for accepting an input indicative of geographical positional information and means for modifying the illumination cycle of the apparatus in response thereto, which positional information may be provided by means of signals derived from a geopositional satellite radio transmitter or transmitters, and the illuminating means including a radio receiver or receivers for the reception of such geopositional signals.

The illuminating means may further comprise means for

monitoring the steady state, or baseline, of the body circadian rhythm, and for monitoring the shift or degree of movement therein taking place in the subject body.

The monitoring means may be temperature sensing means positioned to sense the body temperature, which may also be enabled to sense the body minimum temperature.

The light source of the illuminating means is preferably positioned to lie over and apply light to a blood vessel or vessels in or below the skin, and may include positioning means to locate the light source above the blood vessel or vessels thereby to maximise the effect of light thereon. The positioning means may be temperature sensing means able to locate the position of the underlying blood vessel or vessels, or doppler blood flow sensing means able to locate the position of the underlying blood vessel or blood vessels.

The light source carrier may be applied to inner wrist, or to the rear of the knee joint.

These and other aspects of the present invention will be apparent from the specific embodiments of the invention described herein with reference to the accompanying drawings of which:

Figure 1 shows apparatus in accordance with the invention for attachment to a human wrist;

Figure 2 shows one view of the apparatus of Figure 1 when attached to a wrist;

Figure 3 shows a further view of the apparatus of Figure 1 attached to a wrist;

Figure 4 shows details of a power conducting strap for the apparatus of Figure 1;

Figure 5 shows a block schematic diagram of the essential elements of the apparatus of Figure 1;

Figures 6, 7 and 8 show block diagrams indicating the operation of simple circadian rhythm adjustment apparatus in accordance with the invention; and

Figures 9, 10, 11 and 12 show block diagrams indicating the operation of more complex circadian rhythm adjustment apparatus in accordance with the invention.

Referring to Figures 1 to 3, wrist mountable apparatus in accordance with the invention comprises a controller 10, a light source carrier 12, incorporating a number of individual light sources, which may, for example, be light emitting diodes, mounted or encapsulated in the carrier 12 to provide a composite light source 14, which, when energized, irradiates the inner surface of a wearer's wrist, and more particularly blood vessels in or below the surface of the skin, lying below the light source.

The controller 10 incorporates a series of controls 16 enabling user operation and programming of the energisation of the light source 14, which may be powered by batteries housed in the controller 10, or housed elsewhere, for example in a separate battery pack.

Controller 10 is provided with a display 17 enabling the user to verify the state of operation of the controller, and to verify instructions given to the controller 10 by means of controls 16 during a programming

operation.

Electrical connection between the controller 10 and the light source 14 is by means of conductive strips or wires embedded in the wrist strap 18 which carries the controller 10 and carrier 12, and enables the complete assembly to be mounted upon the user's wrist. Strap 18 may be provided with adjustment means, not here shown enabling the assembly to be adjusted to fit wrists of differing sizes.

Details of such a wrist strap 18 are shown in Figure 4. Strap 18 may be woven of nylon, be provided with VELCRO or other cooperating fastening means 19 at either end, and incorporate three braided copper strips 20, which may be overlain with coloured strips such as 22, to indicate the polarity of the underlying strip, when connected to the battery in, or associated with, controller 10. Connection to the conductive 20 strips at the controller 10 or light source carrier 12 may be by means of conductive power probes 24 which pierce the outer surface of the strap 18, and make electrical contact with the underlying copper strips 20. Controller 10 and light source carrier 12 respectively may each be retained within a frame 26 by projections 28 which pass through apertures 30 in frame 26, positioning of controller 10 or carrier 12 into position causing probes 24 to pierce the outer surface of the strap 18 and make contact with underlying conductive strips 20.

The essentials of the assembly of Figure 1 are illustrated in Figure 5, and comprise a battery power

supply 30, the light source 14 within carrier 2, and a switch 32, which may be operated manually, or, as shown, under the control of programmable switching controller 34, to determine the times and durations for which the battery power supply 30 energises the light source 14 to provide illumination to underlying body surface.

In operation the assembly is mounted upon a user's wrist, with the controller 10 outerwards, and the light source 14 arranged to illuminate blood vessels and/or other receptors lying on and below the skin of the inside of the wrist as shown in Figure 3.

The controller 10 and light source 14 may alternatively be mounted about, for example, the leg of a user, the carrier 12 lying behind the knee and illuminating, when energised, the skin surface, and underlying blood vessels and/or other circadian receptors, to the rear of the knee joint.

To make maximum effective use of the illumination power available from the light source 14, powered from a portable power source such as battery 30, the light source 14 must be accurately positioned above the blood vessel or vessels to be illuminated to achieve the greatest intensity of illumination. This may be achieved by including blood vessel locating means, such as a blood temperature detector or a doppler blood flow detector within the carrier 12, positioned relative to the light source 14 such that accurate location of the carrier 12 above the blood vessel or blood vessels ensures optimum illumination thereof from

light source 12.

The times and durations of energisation of the composite light source 14, and hence of the illumination of the skin of the subject, is controlled by controller 10 switching the power source to the light source 14 either manually or in accordance with the controller internal program, as established by user instructions given by means of controls 16.

The controller 10 may additionally be provided with means enabling it to operate in accordance with one or more of the operational block diagrams of Figures 6 to 12.

Figure 6 is representative of the simplest of systems in which the light source 14 is switched on and off under user control.

In Figure 7 the controller 14 incorporates a timer enabling the light source 14 to be switched off at the end of a predetermined period after the source has been initially switched on, giving a signal to the user of the discontinuance.

Figure 8 illustrates a system in which the time and duration of the light source 14 being on, and the time and duration of light avoidance may be set by the user, controller 10 switching light source 14 on and off appropriate to the selected sequence of operation.

Figure 10 represents a more complex system in which the time of occurrence of body temperature minimum, an important indicator of internal clock time, is calculated from the user's sleep patter data input into the controller

together with time zone details, to provide light source 14 switching patterns and light avoidance period signalling for the user.

In the system of Figure 9, actual body temperature information is derived from a body temperature monitor, the time of occurrence of body minimum temperature sensed, for example by use of a thermocouple or other suitable device attached to the user's body at an appropriate point, and a signal input into the controller 10, together with manually entered time zone details to provide light source 14 with switching patterns as in Figure 10.

The systems of Figures 11 and 12 have signals from geostationary position satellite signals received via a GPS satellite signal radio receiver incorporated into controller 14, injected into the controller in place of the manually entered journey details entered into the systems of Figure 7 and Figure 8 respectively.

In the Figure 11 and 12 configurations the geostationary satellite signals determine the direction of travel of the user: east/west or west/east.

Actual body temperature monitoring as in Figure 9 and Figure 11, enables the baseline circadian profile of the user to be determined. Obtaining a large shift in a user's circadian rhythm is most effectively achieved by presenting the light input at a time closely related to the body temperature minimum, a temperature monitor input enabling this to be accurately achieved.

For the purposes of the invention, light source 14 is

configured to provide light to the skin at an intensity of between some 2500 lux and 25000 lux, in order to stimulate blood vessels and/or other circadian receptors in the skin and thereby modify the circadian rhythm of the user.

The individual light elements in the composite source may be light emitting diodes as described in relation to Figures 1 to 3, but other light sources, for example krypton lamps, may also be used. Lamp efficiency together with battery life and temperature rise at the skin surface have all to be taken into consideration in devising different realisations of apparatus in accordance with the invention.

It will be appreciated that although for user convenience an apparatus is described in which the chosen surface for illumination is the user's wrist, other areas of the body surface may be employed, such as the leg, earlobe, or neck.

Similarly although the apparatus has been described principally in relation to its use for circadian rhythm shifting to counteract the effects of "jet lag", it may also be used for circadian rhythm shifting for other purposes such as correction for delayed sleep syndrome, shiftwork, seasonal affective disorder and to improve the efficiency of treatments such as drug administration.

It will also be apparent that although the specific embodiments of the invention described operate to produce a shift of circadian rhythm by application of light at a time closely related to the body minimum temperature, the

invention is equally applicable to circadian rhythm modification by means of simulated dawn and dusk cycles, that is by a respective gradual raising and lowering of the intensity of the light level applied to the subject, extra-ocularly, at specific times, under the control of controller 10.

#### Claims

1. A method of adjusting the circadian rhythm of a human body by means of the application of light, extraocularly, to one or more areas of the body surface, at appropriate times and for appropriate periods, in accordance with a pre-determined program, thereby to cause adjustment of the body circadian rhythm.
2. A method in accordance with Claim 1 in which the application of light is to blood vessels lying in or below the skin of the body.
3. A method in accordance with Claim 2 in which the application of light is to blood vessels lying in or below the skin surface of the inner wrist.
4. A method in accordance with Claim 2 in which the application of light is to blood vessels lying in or below the skin surface to the rear of the knee joint.
5. Means for applying light, extra-ocularly, to an area or areas of the surface of a human body, in combination with means for controlling the periods and durations of the application of light, thereby to cause adjustment of the circadian rhythm of the body.
6. Means in accordance with Claim 5 in which the means for applying the light comprises one or more light sources mounted within a carrier capable of being applied to a body surface.
7. Means in accordance with Claim 6 in which the carrier is attachable to the body surface.

8. Means in accordance with Claim 7 in which the carrier is attached to the body surface by means of a strap or straps, or the like.
9. Means in accordance with any one of Claims 6, 7 or 8 in which the carrier is at least partially flexible in order that it may be wrapped around a curved body surface.
10. Means in accordance with any one of Claims 4 to 9 in which the light source comprises one or more electrically-powered light emitting devices.
11. Means in accordance with Claim 10 in which the light source comprises one or more light emitting diodes.
12. Means in accordance with Claim 10 in which the light source comprises one or more krypton lamps.
13. Means in accordance with any one of Claims 10, 11 or 12 in which the light source is powered from an electrical power source through a flexible braided conductor.
14. Means in accordance with Claim 13 in which the flexible braided conductor is woven into one or more of the strap or straps for attaching the carrier to the body surface.
15. Means in accordance with any one of Claims 5 to 14, comprising a light source powered by an electrical power source, switched by the controlling means to provide the necessary illumination.
16. Means in accordance with Claim 15,  
in which the controlling means is a switch, manually operated according to a pre-determined sequence to provide light at the appropriate time and for the appropriate

durations, in accordance with a previously determined program.

17. Means in accordance with Claim 15 in which the controlling means includes timing means capable of being pre-programmed to provide the necessary switching of the light source without further intervention of the subject.

18. Means in accordance with Claim 17 in which the controlling means further comprises means for accepting an input indicative of geographical positional information and means for modifying the illumination cycle of the apparatus in response thereto.

19. Means in accordance with Claim 18 in which the positional information is provided by means of signals derived from a geopositional satellite transmitter or transmitters.

20. Means in accordance with Claim 19, including a receiver or receivers for the reception of such geopositional signals.

21. Means in accordance with any one of Claims 15 to 20 in which the controlling means further comprises means for monitoring the steady state, or baseline, of the body circadian rhythm, and for monitoring the shift or degree of movement therein taking place in the subject body.

22. Means in accordance with Claim 21 in which the monitoring means is temperature sensing means positioned to sense the body temperature.

23. Means in accordance with Claim 22 in which the monitoring means senses the body minimum temperature.

24. Means in accordance with any one of preceding Claims 5 to 23, in which the light source is positioned to lie over and apply light to a blood vessel or vessels in or below the skin.
25. Means in accordance with Claim 24 including positioning means to locate the light source above the blood vessel or vessels thereby to maximise the effect of light thereon.
26. Means in accordance with Claim 25 in which the positioning means is temperature sensing means able to locate the position of the underlying blood vessel or vessels.
27. Means in accordance with Claim 25 in which the positioning means is doppler blood flow sensing means able to locate the position of the underlying blood vessel or blood vessels.
28. Means in accordance with any one of Claims 5 to 27 in which the carrier is applied to inner wrist.
29. Means in accordance with any one of Claims 5 to 27 in which the carrier is applied to the rear of the knee joint.
30. Means for applying light in accordance with any one of Claims 5 to 29, in which the illumination level applied to the body surface is gradually increased and/or gradually decreased over a period or periods.
31. Means in accordance with Claim 30 in which the period or periods may be pre-set by the user.
32. Means for applying light extra-ocularly to a living body as described herein with reference to Figures 1 to 5

of the accompanying drawings.

33. Means for applying light extra-ocularly to a living body as described herein with reference to any one of Figures 6 to 12 of the accompanying drawings.

34. Method of applying light extra-ocularly to a human body as herein described with reference to the accompanying drawings.



Application No: GB 9902350.9  
Claims searched: 1-34

Examiner: Mrs Susan Chalmers  
Date of search: 8 March 1999

**Patents Act 1977**  
**Search Report under Section 17**

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK CI (Ed.Q): A5R: REHR

Int CI (Ed.6): A61N: 5/06

Other: ONLINE: EPODOC, WPI, JAPIO, CAS, BIOSIS, MEDLINE

**Documents considered to be relevant:**

Category	Identity of document and relevant passage	Relevant to claims
X	EP 0736307 A2 (KAMEI) see Figures 10 -19 and page 9 line 26 to page 10 line 6, page 10 line 33 to page 11 line 29 and page 12 line 31 to page 14 line 23	5-11, 15-17, 24, 25
P,X	WO 98/51372 A1 (CORNELL RESEARCH) see Figure 1, page 7 lines 10-31, page 16 line 25 to page 17 line 6 and the Examples	1,2,4-10,15,16, 21-25,29
X	WO 95/19809 A1 (BIOLIGHT) see whole document	5,6,10,15-17,24,25

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.